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AUTHOR Hankins, Huana; Thompson, Richard A.
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ABSTRACT

An investigation was undertaken to measure objectively children's eye movements to determine whether the effect of fatigue of the average school day decreases eye movement efficiency, suggesting that children might benefit more from reading instruction in the morning than in the afternoon. Using a photoelectric instrument designed to graph eye movement while reading, 30 second grade students, divided into two groups, were tested both in the morning and in the afternoon. The children were asked to answer comprehension questions at the conclusion of each reading, to indicate that reading was actually taking place. The graphs were hand scored and analyzed by computing (1) number of eye fixations per 100 words, (2) number of regressions per 100 words, (3) span of recognition, (4) duration of fixation, and (5) rate with 70% comprehension. The results found no significant difference between group means for the five variables of eye movement during reading in the morning and reading in the afternoon. (HTH)

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EYE MOVEMENT ANALYSIS OF SECOND GRADE CHILDREN

By: Huana Hankins and Richard A. Thompson

INTRODUCTION

Background and Significance of Study

For years a subject of debate among primary teachers has been whether children benefit more from reading instruction in the morning than in the afternoon. However, when attempting to justify either stand teachers find very little evidence other than personal, subjective conclusions on which to base their opinions.

The problem is one of the effect of fatigue resulting from the average school day upon reading efficiency. There is a dearth of research that would have direct bearing on this particular facet of reading instruction with which teachers must deal every day.

Two notable studies have been conducted in recent years which explore problems related to the connection between time of day and learning. Both of these studies indicate a need for further investigation. Schukert and Touchton (1968) found no significant differences in the amount of fatigue demonstrated by pre-school children in the mornings than in the afternoons. Osborne (1970) conducted research in which experiments, as a group, did seem to indicate that the time of day is an important factor in a stressful situation. These

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research studies indicate that there may be a relation between time of day and potential learning efficiency, but provide no conclusive evidence to this effect.

According to Spache, information about the efficiency of a reader can be accurately and objectively observed by use of a photoelectric instrument designed to graph eye movement patterns (1966).

No significant difference between eye movement efficiency in the mornings and eye movement efficiency in the afternoons could indicate that second grade children may benefit from reading instruction in the afternoons as much as from reading instruction in the mornings.

Purpose of Study

This investigation was undertaken to objectively measure eye movements to ascertain if eye movements of second graders are different in the morning from the afternoon.

Hypothesis

There was no significant difference between group means for five variables of eye movement (the number of fixations per 100 words, number of regressions per 100 words, average span of recognition, average duration of fixation, and rate with comprehension) during reading in the morning and reading in the afternoon.

Definition of Terms

A fixation is each stop the eyes make when moving across a line of print.

A regression is a fixation which is made after a reverse (right to left) movement.

The average span of recognition is the amount of printed material taken in per fixation.

The average duration of fixation is the number of fixations divided into the amount of time taken to read a given number of words.

The rate with comprehension is the time required to read a given number of words, answering comprehension questions at the end of the selection with 70% accuracy.

Efficiency is the time and effort consumed and the visual approach used.

Limitations of the Study

It should be noted that this study was performed on members of a particular Second Grade Class.

It is possible that general fatigue was not as evident in the testing process as it might be in the actual reading process at the same time of day due to the Hawthorne effect.

The graphs were personally collected by the researcher after training in use of the testing instrument by technicians in a local optometrist's office until reaching a level of proficiency

determined by the technicians to be satisfactory.

Though the graded paragraphs which the children read had an acceptable average readability level, the readability of each paragraph may not be constant. However, an attempt was made to provide the same selections for all children on each level.

Assumptions of the Study

It was assumed in this study that:

No upsetting events had occurred prior to a testing which might have negatively affected the results.

All children had comparable schedules during the day requiring the same amount of exertion.

Children did not experience anxiety during the first testing.

CHAPTER II

A REVIEW OF RELATED LITERATURE

Contrary to what most people believe, researchers have observed that eyes do not make a continuous sweep across the printed line. Instead, they move in a sequence of jumps (interfixation movements) and pauses (fixations) in a left to right order across a line of print. It is during the fixation that actual reading takes place since vision is blurred during the interfixation movement. Sometimes the eyes make a backward movement and pause when the material has not been sufficiently recognized or understood. This is referred to as a regression. When one line of print has been read, the eyes should then make a return sweep to the left and repeat the process beginning at the next line. This process has been readily observed in a variety of ways, of which one of the more recent is a photoelectric graph recording of the eyes while actually reading.

There have been numerous research experiments dealing with eye movements which have contributed greatly to the educator's understanding of how children learn to read. There have been relatively few designed to explore the effects of environmental factors upon the process of reading.

Without doubt, reading, with all its mental and physical activity, requires the consumption of a great deal of energy.

Huey (1968) states:

> We must remember that even for all classes of readers, reading even at its best and pleasantest requires the expenditure of much energy and is reductive of nerve reserve.

Carmichael and Dearborn (1972) maintain that:

> Only by the use of many different approaches can an increasingly useful and explicit knowledge be secured of the varied phenomena of human work called by the single name fatigue ... should fatigue be considered as akin to exhaustion, the depletion of energy supplies, or the curtailment of activity by toxic substances, the responses of the organism involved in reading behavior would presumably be affected.

Carmichael and Dearborn (1972) also point out that the literature on fatigue indicates that a person may be able to continue working satisfactorily even when the desire to do so is missing. Furthermore, these authors suggest that a student can condition himself to tolerate feelings of fatigue, refusing to let them interfere with reading performance.

Spache (1966) maintains that if it becomes necessary to make compensatory adjustments that one can expect "high degrees of tension, excessive energy demands, rapid fatigue, and consequent distaste for reading." In addition, differences in comprehension may be noted.

In a study designed to relate variations in teacher participation to measures of child fatigue in pre-school training programs, Schukert and Touchton (1968) did not find a significant

difference in the time of day as related to the degree of fatigue in pre-school children. It was reported, though, that a tendency did exist for more symptoms of fatigue to be consistantly observed more in the afternoons than in the mornings. It is interesting that the children observed showed considerably more symptoms of fatigue on Mondays, both in the morning and in the afternoon. Also of interest is the fact that boys exhibited fatigue symptoms at a ratio of nearly double that recorded for girls.

Osborne (1970) investigated the connection between time of day and learning in a stressful situation by performing a series of five experiments designed to assess the effects of this variable, using albino rats as subjects. Osborne was not able to find sufficient evidence in any single experiment to show that a relationship does exist between the factors, but does report that the experiments as a whole suggest that time of day could be an important factor affecting learning in a stressful situation. Projecting that time of day could possibly affect human learning as well, he suggests that fear of failure in a classroom could produce a stressful situation.

Anderson (1974) conducted an eighteen-week study to determine whether the time of day would affect the achievement of ninth grade remedial reading students in the areas of comprehension and vocabulary. Comparisons were made be-

tween ten students attending the Remedial Reading Laboratory in the morning and ten students attending in the afternoon. Pre-test and post-test results from the Gates-MacGinite Reading Survey, Form D,3M were used to make the comparisons. No significant difference was found between the achievement of the morning group and the afternoon group. Anderson recommended further study concerning the time of day factor as a basis for achievement.

Summary of Review of Related Literature

Educators and researchers are not sure of the role of fatigue upon learning at this time. There seems to be a general feeling that a negative influence of fatigue upon learning is present, even if only to an attitudinal extent. Schukert and Touchton (1968) cite more observed symptoms of fatigue in preschoolers during the afternoons than mornings. Osborne (1970) also finds indications in his research that time of day can affect human learning. However, no conclusive evidence is present to support any connection between the effect of time of day upon reading instruction. Certainly there is need for further investigation into this variable of reading instruction.

CHAPTER III

DESIGN OF THE STUDY

Population Selection

The subjects in this study were members of one Second Grade class at Forest City Elementary School, Seminole Co., Florida. There were thirty students in the class; twelve boys and eighteen girls. All students were Caucasian and largely from middle class backgrounds. The second grade at this school was grouped at the beginning of the year by reading level, with the students in this particular class being those with the highest level of achievement. All students in the class were reading on the 3^1 level, as measured by the Seminole County Reading Objectives.

Procedures for Collecting Data

The instrument used in this study was the EDL/Biometrics Reading Eye II. This is a photoelectric instrument designed to graph eye movement patterns while reading. In this investigation, the instrument was used to record each subject's eye movements while reading in the morning and in the afternoon.

Before the test date a level of reading difficulty suitable for each subject was determined by having each subject read graded test selections. The highest test selections in

which the subjects made five or less errors determined a suitable level. Care was taken not to use the test selections that would be employed during actual testing.

Two days before the test was begun the instrument was brought into the classroom and demonstrated, using children from another class. Opportunity was given for questions and answers. Each child in the class was allotted time to sit with the machine and become acquainted with its "feel" and function.

It was desirable to graph students within a maximum time span of one hour and forty five minutes per graphing session, in order to provide sufficient time lapse between morning and afternoon graphings. In order to accomplish this with the large number of students to be tested, the class was randomly divided into two groups, Group A and Group B. The test was given twice, with each test taking two days. The morning graphings were taken from 9:15 a.m. to 10:30 a.m. The afternoon graphings were taken from 2:00 p.m. to 3:15 p.m. Group A was given the test on the morning of the first day and the afternoon of the second day. Group B was given the test on the afternoon of the first day and the morning of the second day. This procedure was repeated for the second testing. Directions for testing on pages 23-28 of the manual were followed as closely as possible. Different test cards were given to each student for the morning and afternoon testings as well as for first and second testings.

Comprehension questions were answered at the conclusion of each graphing which required the children to answer with 70% accuracy to indicate that reading was actually taking place.

Procedures for Treating Data

Graphs were hand scored by the examiner, following closely the guidelines given in the manual for the instrument. Each graph was analyzed by counting or computing the following:

1. Number of fixations per 100 words.
2. Number of regressions per 100 words.
3. Span of recognition.
4. Duration of fixation.
5. Rate with 70% comprehension.

A t-test was used to determine the significance of difference between group means for each variable obtained from the morning and afternoon graphs. The hypothesis was tested at the .05 level of significance.

FINDINGS OF THE STUDY

The basic purpose of this study was to ascertain whether the effect of fatigue resulting from the average school day decreased eye movement efficiency when reading in the afternoon.

The stated hypothesis was that there would be no significant difference between group means for five variables of eye movements (the number of fixations per 100 words, the number of regressions per 100 words, the average span of recognition, the average duration of fixation and the rate with comprehension) during reading in the morning and reading in the afternoon.

Students were randomly divided into two groups, group A and group B. In a four-day time period the students were tested twice, with each test consisting of one morning graphing and one afternoon graphing.

Each graph was analyzed by counting or computing five variables: the number of fixations per 100 words, the number of regressions per 100 words, the span of recognition, the duration of fixation and the rate with 70% comprehension.

A t-test was used to determine the significance of difference between group means for each variable.

The following tables provide a comparison of mean differences for the five variables considered in this study.

Table I contains data regarding the first variable, the number of fixations per 100 words. As indicated, there was found to be no significant difference between group means for this variable for either group A or group B, for the first or second testings.

TABLE 1

A COMPARISON OF MEAN DIFFERENCES OF THE NUMBER OF FIXATIONS PER 100 WORDS FOR GROUP A AND GROUP B

Group	Test	Morning		Afternoon		Mean Difference	T * Value
		$\bar{x}$		$\bar{x}$			
A	1	129.7	32.43	124.5	24.43	5.27	.92
	2	123.1	18.12	126.4	24.02	-3.27	-.56
B	1	133.7	30.95	125.2	28.93	8.47	1.13
	2	129.7	16.87	127.5	30.60	2.13	.25

*D.F. 14 Not Significant at .05 level

Table II contains data regarding the second variable, the number of regressions per 100 words. There was found to be no significant difference between group means for this variable for either group A or group B, for the first or second testings.

TABLE 2

A COMPARISON OF MEAN DIFFERENCES OF THE NUMBER OF REGRESSIONS PER 100 WORDS FOR GROUP A AND GROUP B

Group	Test	Morning $\bar{x}$		Afternoon $\bar{x}$		Mean Difference	T * Value
A	1	26.6	17.53	27.6	14.14	-1.00	-0.35
	2	26.5	13.17	27.0	13.39	-2.53	-0.18
B	1	26.9	17.89	24.1	10.99	2.73	0.68
	2	26.6	8.91	26.8	15.05	-0.20	-0.04

*D.F. 14 Not significant at .05 level

Table III contains data regarding the third variable, the span of recognition. Again, there was found to be no significant difference between group means for this variable for either group A or group B, for the first or second testings.

TABLE 3

A COMPARISON OF MEAN DIFFERENCES OF THE AVERAGE SPAN OF RECOGNITION FOR GROUP A AND GROUP B

Group	Test	Morning		Afternoon		Mean Difference	T * Value
		$\bar{x}$		$\bar{x}$			
A	1	578	289.8	595	284.7	-16.67	-0.75
	2	602	291.3	641	243.6	-39.13	-0.67
B	1	510	313.8	541	328.1	-30.73	-0.27
	2	606	229.4	522	300.6	83.93	1.08

*D.F. 14 Not significant at .05 level

Table IV contains data regarding the fourth variable, the average duration of fixation. Again, there was found to be no significant difference between group means for this variable, for either group A or group B, for the first or second testings.

TABLE 4

A COMPARISON OF MEAN DIFFERENCES OF THE DURATION OF FIXTATIONS FOR GROUP A AND GROUP B

Group	Test	Morning		Afternoon		Mean Difference	T * Value
		$\bar{x}$		$\bar{x}$			
A	1	369	109.2	363	133.5	6.07	.36
	2	345	105.6	346	105.2	-0.666	-0.05
B	1	289	102.3	290	113.9	-0.533	-0.05
	2	294	92.82	306	104.7	-11.73	-1.29

*D.F. 14 Not significant at .05 level

Table V contains data regarding the fifth and last variable of the study, the rate with comprehension. Once more, there was found to be no significant difference between group means for this variable for either group A or group B, for the first or second testings.

TABLE 5

A COMPARISON OF MEAN DIFFERENCES OF THE RATE WITH COMPREHENSION FOR GROUP A AND GROUP B

Group	Test	Morning		Afternoon		Mean Difference	T * Value
		$\bar{x}$		$\bar{x}$			
A	1	121.6	31.12	125.6	33.67	-4.0	-0.71
	2	128.4	31.67	125.7	33.52	2.73	0.53
B	1	133.0	64.39	142.7	66.36	-9.73	-1.10
	2	125.7	43.42	126.9	44.00	-1.13	-0.16

*D.F. 14 Not significant at .05 level

CHAPTER V

SUMMARY AND CONCLUSIONS

Few research studies have been undertaken to explore the connection between time of day and learning. Those which have been undertaken have failed to uncover any significant connections between the variables. Yet many teachers, in the primary grades, especially, continue to insist that reading instruction is most effective during the morning hours.

The purpose of this study was to determine whether the effect of fatigue resulting from the average school day decreases eye movement efficiency perhaps indicating that second grade children may benefit more from reading instruction in the mornings than in the afternoons. The hypothesis was that there was no significant difference between group means for five variables of eye movements (the number of fixations per 100 words, number of regressions per 100 words, average span of recognition, average duration of fixation, and rate with comprehension) during reading in the morning and reading in the afternoon.

Data was gathered by use of the EDL/Biometrics Reading Eye II, a photoelectric instrument designed to accurately and objectively graph eye movement patterns while the subject is reading.

In this study, students were tested twice, with each test consisting of one morning graphing and one afternoon graphing. Each graph was analyzed in order to count or compute each variable of the stated hypothesis. A t-test was used to determine the significance of difference between group means for each variable of the hypothesis.

The findings indicate that for this particular group of Second Grade Students, there was no significant difference between group means for the five variables of eye movement during reading in the morning and reading in the afternoon.

This information suggests that the time variable does not cause variance in eye movement efficiency, and supports the teaching of reading either in the morning or in the afternoon with expectations of equal eye movement efficiency.

RECOMMENDATIONS

Based upon the findings and conclusion of this study the following recommendations are submitted:

1. It is possible that, while group means did not reveal a significant difference in any of the variables between morning and afternoon testings, that individual mean differences would have indicated that certain individuals do indeed perform more efficiently in the morning or even in the afternoon. Further statistical analysis would be of interest.

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2. The population in this study consisted of those Second Graders in this School who were highest in reading achievement. Further study should be done to determine if the same results are obtained from another group of second graders having a lower level of reading achievement.
3. This study should be repeated using representative samples of students at other grade levels.
4. This study would have interesting implications if repeated and correlated with controlled variables of sleep, diet or other factors influencing fatigue.

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